BEYOND GEOMETRY: FROM CANDELA'S MATERIAL EXPERIMENTS TO PRODUCTORA'S ANTICIPATING FORMS

MÁS ALLÁ DE LA GEOMETRÍA: DE LOS EXPERIMENTOS MATERIALES DE CANDELA A LAS FORMAS ANTICIPADAS DE PRODUCTORA

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Abstact: *Félix Candela is best known for his innovative hyperbolic paraboloid (hypar) geometry, his structural surfaces that resulted in extremely thin concrete roofs with a new scale and material efficiency, as well as a unique textural and atmospheric quality. While his work is predominantly valued for its contributions to architectural and structural engineering –a seemingly inescapable reading– it is also important to stress its spatial properties, formal expression, economic conditioning, and social implications. Focusing on these so far understudied aspects of his oeuvre not only allows a reevaluation of Candela's work but also productively entangles his experiments into a wider context: from Mexico's efforts to construct more schools in rural and indigenous communities in the 1940s to contemporary practices like PRODUCTORA and their legible geometries and material precision. As for the latter, Candela's work certainly constitutes a singular contribution, but his influence on generations to come goes beyond the often-celebrated engineering accomplishments of shell construction. In fact, the perceived limitations of his influence might have resulted from an overemphasis on structural and material lessons that over-relied on manual labor.*

Key words: *Candela; Structure; Shell; Concrete; Housing.*

Resumen: *Félix Candela es reconocido por su innovadora geometría paraboloide hiperbólica (hypar), superficies estructurales que dieron como resultado techos de hormigón extremadamente delgados con una nueva escala y eficiencia material, así como una calidad textural y atmosférica única. Si bien su obra se valora principalmente por sus contribuciones a la arquitectura y la ingeniería estructural –una lectura aparentemente ineludible–, también es importante destacar sus propiedades espaciales, su expresión formal, el factor económico y las implicaciones sociales. Centrarse en estos aspectos hasta ahora poco estudiados de su obra, no solo permite una reevaluación de la obra de Candela, sino también integrar productivamente sus experimentos en un contexto más amplio: desde los esfuerzos de México por construir más escuelas en comunidades rurales e indígenas en la década de 1940 hasta prácticas contemporáneas como la de PRODUCTORA, con sus geometrías legibles y precisión material. En cuanto a esto último, la obra de Candela constituye sin duda una contribución singular, con una influencia en las generaciones venideras que va más allá de los celebrados logros de ingeniería de la construcción de cáscaras. De hecho, las limitaciones percibidas de su influencia podrían deberse a un énfasis excesivo en las lecciones estructurales y materiales que dependían excesivamente del trabajo manual.*

Palabras clave: *Candela; Estructura; Envolvente; Hormigón; Vivienda.*

FIG. 01

FIGS. 02 a&b

Félix Candela is best known for his innovative hyperbolic paraboloid (hypar) geometry, his structural surfaces that resulted in extremely thin concrete roofs with a new scale and material efficiency, as well as a unique textural and atmospheric quality. While his work is predominantly valued for its contributions to architectural and structural engineering –a seemingly inescapable reading– it is also important to stress its spatial properties, formal expression, economic conditioning, and social implications. Focusing on these so far understudied aspects of his oeuvre not only allows a reevaluation of Candela's work but also productively entangles his experiments into a wider context: from Mexico's efforts to construct more schools in rural and indigenous communities in the 1940s[1] to contemporary practices like PRODUCTORA and their legible geometries and material precision. As for the latter, Candela's work certainly constitutes a singular contribution, but his influence on generations to come goes beyond the often-celebrated engineering accomplishments of shell construction. In fact, the perceived limitations of his influence might have resulted from an overemphasis on structural and material lessons that over-relied on manual labor.[2]

As a designer of a new architectural space characterized by smooth curvatures and rough concrete, Candela's projects appear on the one hand scale-defying, approximating the sublime; and on the other hand, they seem to be dimensioned for the collective, simultaneously open and differentiated. What in most of his projects materializes as an uninterrupted ground plane, invites everyone and often moves fluently from exterior to interior. Meanwhile, the curvatures of the shell hovering above adeptly structure the space without implementing walls, but by compressing and expanding its height. I am here suggesting a reading of his shells as a collective, open-ended, and inclusive space. And although they are often, and understandably so, perceived as exuberant structural experiments of advanced geometry, Candela saw them as straightforward architectural responses to local urgencies. By utilizing the properties of concrete (a material that had just been accepted for its efficiency, modernist attributes, and formal properties) and disarming the mathematics of shell construction (through emphasis on material experiments), Candela cultivates a spatial and material practice that reflects and is based on the Mexican context.

BUILDING FOR LOCAL URGENCIES

In the summer of 1949, 10 years after his arrival in Mexico, Candela built his first experimental shell. His previous client, Miguel Gomez Lavin, permitted Candela to use a small lot on one of his properties to conduct early trials with lightweight materials, which soon became the setting for his first concrete shells. For a load test on a segment of a straight-edged hyperbolic paraboloid, he successfully stacked close to 30 cement bags, and shortly after, created a funicular vault through formwork made of wooden arches and taut cloth in-between.[3] Once the concrete was poured, the fabric stretched with the weight of the material, creating a curvature that gave it structural rigidity (FIG. 01).[4] While inspired by Robert Maillart's famous 1939 Cement Hall for the Swiss Exposition in Zurich, Candela's work appeared simpler, more straightforward. His experimental vault, for example, was no longer cantilevered but sat firmly on the ground. At first sight, this appears as a regression from the exuberance of Maillart's daring structure, but Candela's consecutive works reveal an intentional reduction in structural effort in order to create a local building response. In contrast to Maillart, he envisioned this type of vault not in the pristine context of an exposition but rather as a rapidly constructed, low-cost model to respond to housing and school building shortages in 1950s Mexico.

As he successfully completed his experimental vault, Candela was drawing proposals for *minimum dwellings* and *low-cost schools*, in which he advertised the vault's efficiency **(FIGS. 02 a & b)**. After proposing multiple projects for rural schools in the State of Tamaulipas and being commissioned to build one near Ciudad Victoria, we read in his monograph, written by Colin Faber in the office of the architect and under his supervision: "Candela erected a similar vault for a small rural school nestling in the Mexican jungle near Ciudad Victoria. Arches for the forms, and all building materials were easily transported in a single truck."[5] Here, the simplicity of hauling material and the speed of construction took priority over possible engineering advances. Instead, the vault was developed so its rapid deployment could reach a community in need. Candela's experiments blended most intimately with the Mexican context, a condition that was to unfold continuously in the coming two decades.

FIG. 03

FIG. 04

SITES AS LABORATORIES

In 1950, Candela, now working under the company's name, Cubiertas Ala,[6] built a second experimental form, a conoid vault, on a site provided by the father of the Fernández Rangel brothers who were partners in the company. The entrepreneur, who manufactured machines to print banknotes, was building a factory in San Bartolo, Mexico City and allowed Cubiertas Ala to use the grounds. Candela saw this as an opportunity to test a vault that was more complex **(FIG. 03)**. While formwork for the conoid vault also deployed straight lines, a series of differently rising arches had to be placed before straight pieces of wooden planks could be attached. The decentering (process of removing the formwork) also proved to be problematic as the concrete was too dry and, in turn, stuck to the mold and had to be removed by force. It was especially in these moments of failure that Candela was able to draw lessons for future projects.

The experimental shell in San Bartolo would become a precursor and starting point for projects like Boliches Marsella (1950-1951), a bowling alley covered by a row of 10 identical cylindrical vaults with a span of 12 meters **(FIG. 04)**. Just as in San Bartolo, the columns would reach beyond the vault and were connected with tension rods above. Its seriality and use of tension cables meant that the formwork could be lowered, moved, and reused effortlessly. Placing vaults as a series of uniform structures in order to cover larger areas would become a key aspect in the work of Cubiertas Ala, enabling the firm to build a system that could easily expand and adapt. Furthermore, the repetition of the same structure over a larger space became not only highly efficient through the reuse of formwork, but also permitted for serial testing, adjustments on site, and iterative improvements of the structure.

As Cubiertas Ala secured more commissions, these construction sites often fulfilled the secondary purpose of providing the arena for further trials of yet untested structures, which for Candela would become the primary focus. What emerges is a doubling and layering of the site as a terrain where multiple experiments run in parallel. Candela's sites are no longer simply the final locations for architecture; they became locations of conjecture and speculative forecasting –a place where the unknown is tested, and forms of the future briefly appear–. It is no coincidence that sites for commissioned commercial work became the experimental ground for new conjecture, given the resources of these projects. Building was here an act of experimentation, to verify proof of concepts, and to project beyond a given brief.

TURNING FOUNDATIONS INTO ROOFS

Just as he had previously asked factory owners to provide the ground for tests, he would soon use his own construction sites to double as laboratories to trial forms that would later be implemented. According to Carlos Recamier, who directed the large project for three customs warehouses: "Felix asked my permission to do an experiment, and I of course agreed. He then took a few construction workers to an area of the site that we were not using and erected a small umbrella."[7] "When the time came to remove the formwork," Recamier recalled, "nobody wanted to go near it. They all thought it would fall down. So, he [Candela] took a sledgehammer and began to knock away the poles. Once the others saw that it stood up, they started to help him. [...] Then, Candela asked his workers to climb with him onto the structure to check its rigidity, and when everybody was up [on the umbrella], I grabbed a camera and took the photograph that was later published everywhere"[8] **(FIG. 05)**.

Even though Cubiertas Ala was building its largest commission yet,[9] Candela had apparently moved on, seeking a proof of concept for a new type of structure that could cover an area of more than 200 square meters on a single support and a form that could easily be combined into a larger series. Soon, these umbrellas would multiply to form fields of roofs to cover large areas that could be extended with ease. A form that at first suggests singularity was arranged into a larger organization. The scope of possible

FIG. 05

FIG. 07

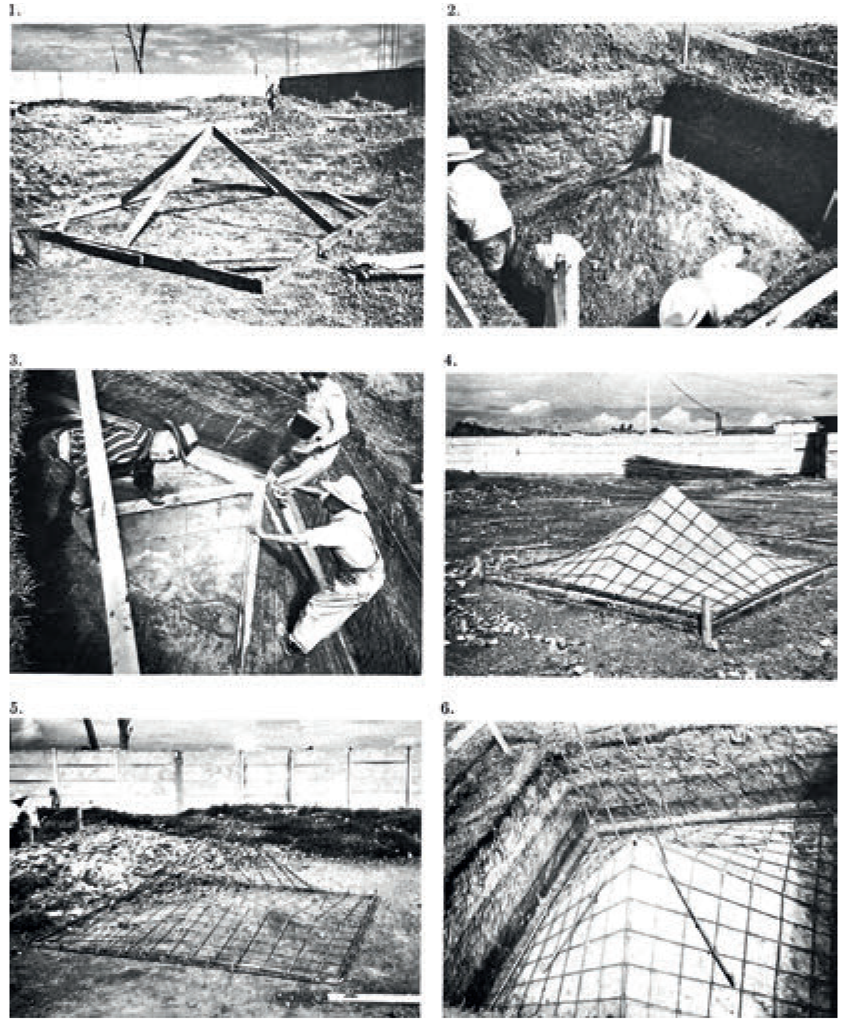


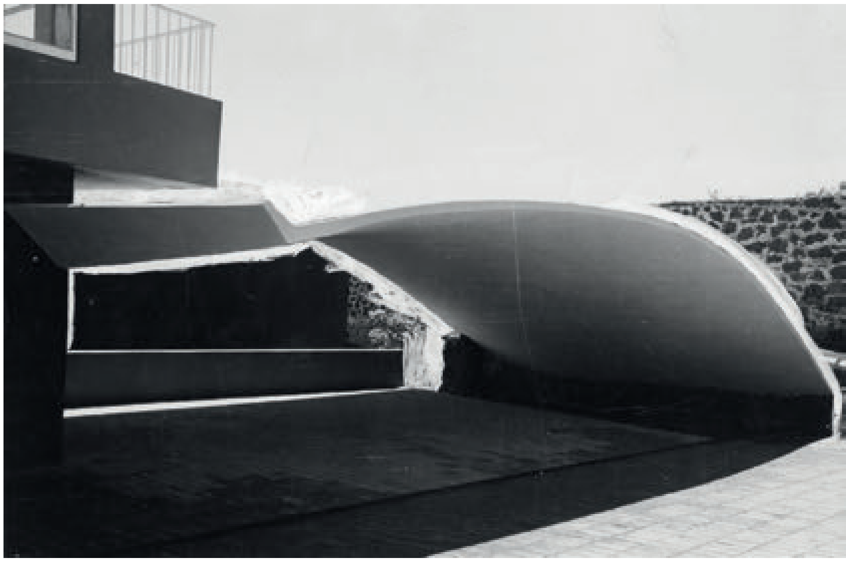
FIG. 06

variations was immense, as the umbrellas could be square, rectangular, rhomboidal, or polygonal in shape. Inverted, the umbrella became a fundamental component of Candela's work. In fact, each column of the warehouses was already held up by inverted umbrella foundations, which offered new, superior possibilities to carry loads in the substandard soil and earthquake-prone conditions of most parts of Mexico (FIG. 06). Thus, even before the umbrellas became roofs that populated large areas of Candela's sites, they spread below ground in sync with the column grid.

Above ground, the spatial effects of the umbrellas as a field condition seemed limitless. Inclining the edges, for example, created a *sawtooth* arrangement that lit and ventilated the interior from above (FIG. 07). At the 1954 Río's Warehouse in Lindavista, Mexico City, the same formwork would be employed numerous times to build segments of the overall structure. This allowed successive, independent construction of parts and the acceleration of construction times. Because of their versatility, expediency, and efficiency, umbrella roofs would eventually become the most sought-after form in the repertoire of Cubiertas Ala—one that eventually would subsidize further experimentation on custom shapes.

HOMES AS PROTOTYPES

Each commission began simultaneously an opportunity to speculate on the potentials and limits of shell construction, as well as on its spatial and formal possibilities. Conscious of the early experiment's breadth of forms, Candela's monograph defines these initial projects by Cubiertas Ala as a "crucial assortment," where each was different from the next, "buil[ding] short and long vaults, prismatic and undulating slabs, cones, conoids, domes, nearly the whole index of known shapes."[10] When Cubiertas Ala signed an agreement with the *Novedades* newspaper to build five houses in the residential neighborhood of Los Jardines del Pedregal in 1951, Candela designed each house entirely distinct, enabling him to test an array of idiosyncratic forms. As he recalled: "We put a shell roof on wherever we could to gain experience."[11] Projects became vessels to trial ideas, and the unique perimeters of the *Novedades* project made it a perfect testbed. To gain new subscribers, the newspaper planned to make headlines by constructing a number of captivating houses that it would raffle off every six months. Here, Candela was unburdened from the demands of more traditional clients.

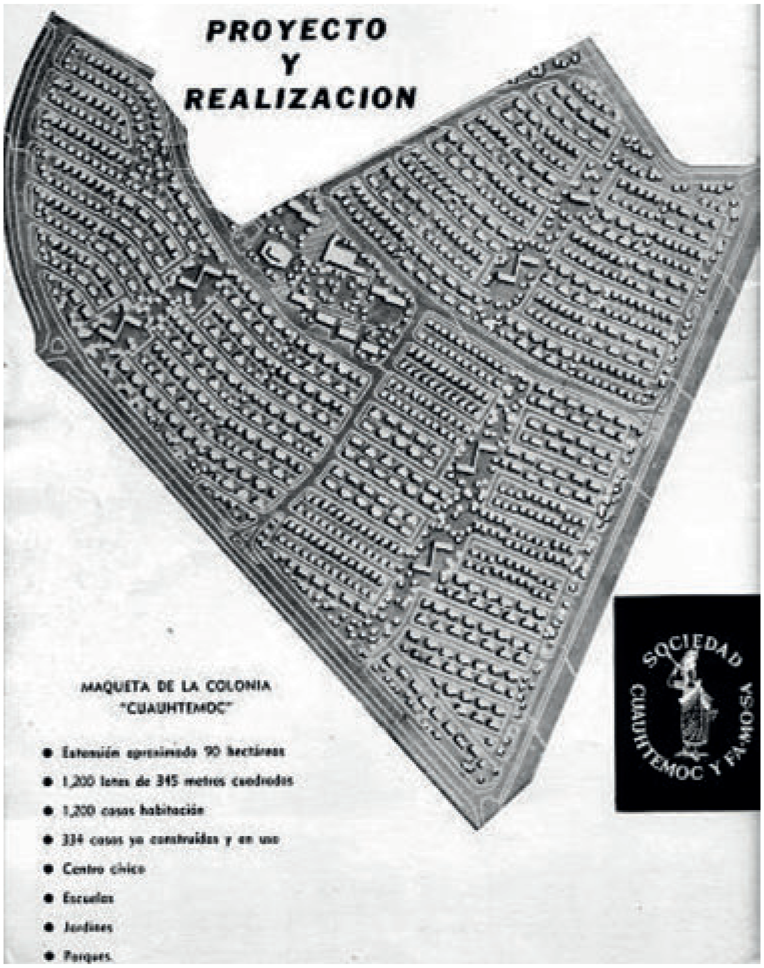


FIGS. 08 a&b

FIGS. 09-10

The first house for *Novedades* was roofed with a spectacular barrel vault that spanned more than 20 meters, the most audacious scale for Candela at the time **(FIG. 08 a & b).** While the newspaper was satisfied with the boldness of the scheme that was destined to make headlines for the raffle, Cubiertas Ala was less pleased. "We lost so much money on that house," Candela noted, "that I tried to make the second one very conventional and cheaper."[12] Adapting his ambitions to the financial realities of construction, he tamed the structure of the houses but increased the number of test sites.[13] More moderate in scale, the second building deployed a folded slab (the first for Candela). Likewise, the entrance to house number three was adorned with a double-cantilevered shell that projected in each direction. Frequently, rather than the roofs of the homes, spaces such as carports, garages, entries, and porticos became the sites for experimentation. In fact, some of the more flamboyant shells appeared in these less representational and more discreet moments.

The carport for the residence of the architect Horacio Almada (1951-52), for example, a doubly curved shell was anchored on one side in the ground and on the other side was braced by a black concrete wall **(FIG. 09)**. The edge of the warped surface appears almost paper thin, and the juxtaposition between the white form and the black support further gives the illusion of a floating sheet, precariously holding its own weight. Most of Candela's structures exude a level of danger or, at the very least, of instability—a quality that Candela seemed to enjoy and sometimes even taunted the inhabitants with. We hear that "steel bars of 1/2-inch were laid in the surface to satisfy the owner's misgivings, and to comply



FIGS. 11 a&b

with the contract, which had specified 'reinforced' concrete."[14] According to Candela, the shape could have stood on its own, but reinforcement was added to give some comfort to the owner, while changing nothing on the dangerously thin and utterly unstable appearance of the shell itself. Often cloaked under the guise of material efficiency and economy, the forms' appearance and their effects on the viewer were of fundamental importance. They were crafted over time and through multiple iterations.

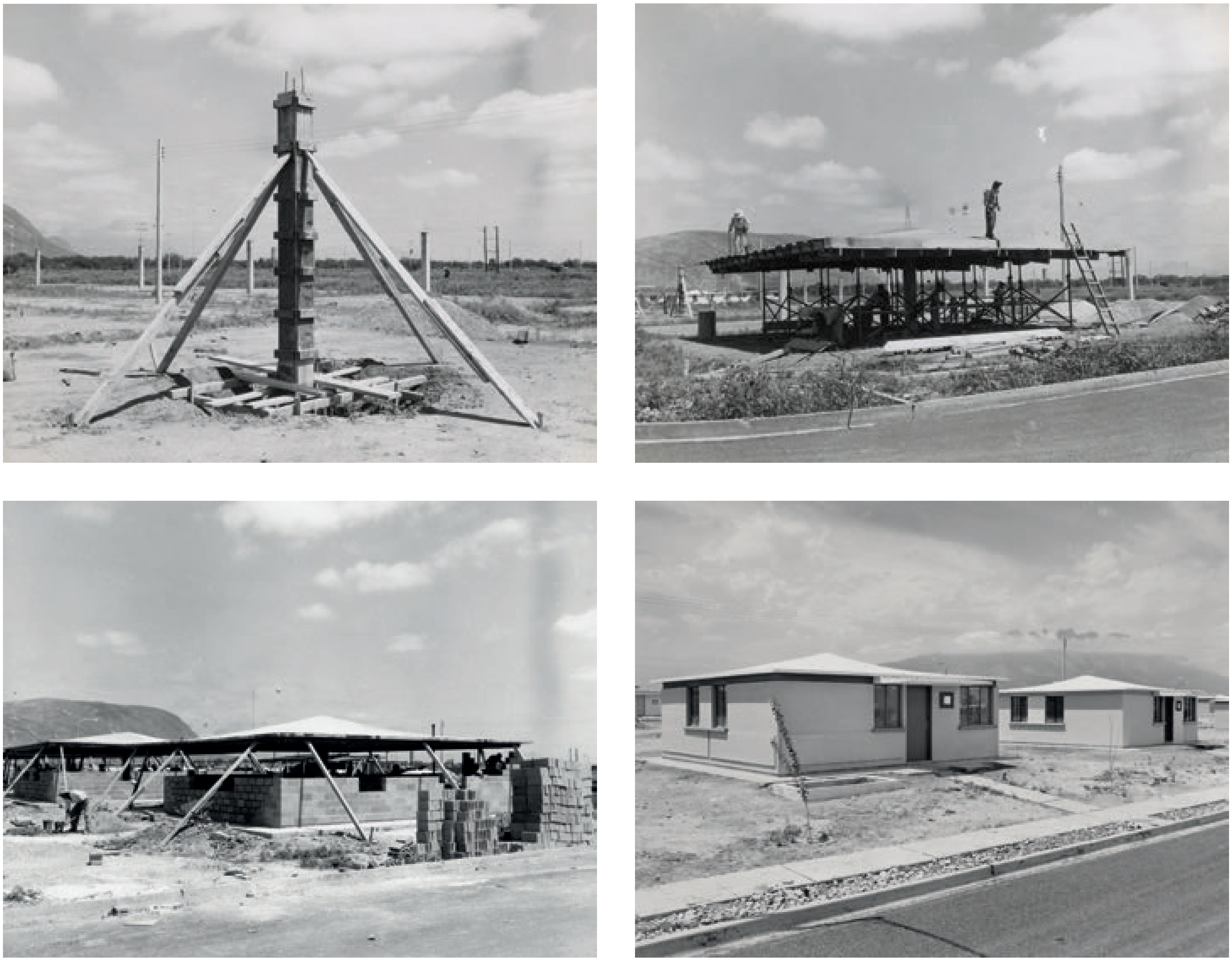
Candela explicitly described the famed 1951 Cosmic Rays Pavilion (Pabellón de Rayos Cósmicos) at the National Autonomous University of Mexico (Universidad Nacional Autónoma de México, UNAM) as a precursor for the Almada carport **(FIG. 10)**.[15] Whereas the former utilizes stiffening arches to support the two shells, the latter omits these with the aim of approximating the limits of shell construction and to create an inexplicably thin surface. The Pavilion was the first time that Candela employed a pure hyperbolic paraboloid, reaching an unprecedented thinness of 5/8-inch to allow for the measurement of cosmic radiation from the inside of the laboratory. This made the Pavilion one of the thinnest concrete structures ever built. But whereas the concrete arches and capped ends of the Pavilion disguise the thinness of the surface, the Almada carport exposes and celebrates its properties, achieving a dazzling image of precarious levitation.

FROM HOUSE TO HOUSING

Candela used the above-mentioned projects to push the spatial and material limits of shell construction and used the insights gained during these experiments to inform projects that required affordability. One of the largest developments in which single-family homes became carriers for thin-shell experiments was a bungalow settlement for more than 100 low-cost houses in Monterrey, Nuevo Leon in 1958 **(FIGS. 11 a & b)**.[16] Built as a workers' town, it was nevertheless recognized for its innovative financing that would become a point of reference for the Institute of the National Housing Fund for Workers (INFONAVIT), founded in 1972. Here, a shallow umbrella was held by a single column and balanced on the exterior walls of the house. In retrospect, Candela noted: "by first building the roof supported by a central column, the walls do not need foundations and the work sequence on the construction site is much more fluid, avoiding interference between different trades or work crews, and a house can be built in 10 days using conventional methods, or in less if a certain degree of prefabrication is used."[17] Precursors of the latter were already introduced by building the shells at ground level and then hoisting them into their final position.

Constructing the roofs with reusable molds, at faster speeds, and with less material than conventional shelters, lowered the cost of each structure and made the scheme highly economical. This enabled an expedient sequence, resulting in a field of new roof forms that was rapidly expressed during construction **(FIG. 12)**. At any given time in the process, one would have seen numerous roofs floating on one column, some supported by formwork, while others were only braced by thin pieces of lumber awaiting the exterior walls to reach the shell and form the soffit.

Furthermore, the dissociation of the wall from the structure gave new flexibility in the interior arrangement.[18] Since the roof was held by a single column, it became possible to transform the interior without structural alterations to the building. At Monterrey, this resulted not only in different housing layouts, ranging in square footage between 64 and 128 m², but the typology also granted the inhabitants to modify the interior configuration of their home. The initial scheme covers two to three bedrooms, a bathroom, and a large social space (including a living room, dining room, and kitchen), yet subdivisions could be taken away or additional walls could be erected. Furthermore, the 345 m²



FIGS. 12

properties permitted the residents to build extensions without requiring the demolition of the hypar roof. While highly economical (something that Cubiertas Ala sought to quantify),[19] the scheme's lightness (a single structural column) provided the residents with a level of freedom and autonomy that affordable housing rarely tolerates.

Not surprisingly, this scheme caught the attention of other Latin-American countries, most notably, post-revolutionary Cuba, for which its new socialist government sought to improve the living conditions in the Cuban countryside. The brief, presented at the *First National Forum on Peasant Housing* (August 16-23, 1959) in Havana, asked for proposals for different assembly systems, aiming at streamlining housing construction in rural areas. Most profoundly, the anticipated schemes should also allow for self-construction by residents in hard-to-reach areas.[20] Even though he had to cancel his physical presence in Havana, his presentation was part of the Forum and his so-called Shell House was included in the exhibition organized by the Department of Rural Housing Construction of the Rebel Army. Although it has not yet been possible to corroborate whether any of this housing ideas were implemented in Cuba, buildings on the island certainly indicate Candela's influence. For instance, the Clodomia Acosta poultry farm was entirely constructed through a series of umbrella shells with a striking resemblance to Candela's earlier roofs. According to Ángel Manuel Álvarez Gómez, these "constitute the largest concentration of umbrellas built in Cuba on record."[21] As this formation of roofs was more recently converted into single-family homes, they document the versatility of the typology, where the roof remains constant above an alternating programmatic ground **(FIG. 13)**. These schemes

FIG. 13

radically rethought the logistics, structure, and aesthetic of pitched roof construction through a system that reversed the conventional flow of assembly, which now began with the roof, an order innate to the geometry of the shell.

DIMENSIONS OF GEOMETRY

So far, Candela's housing projects have rarely been considered,[22] and yet his numerous schemes, involvement with organizations and governments, and notes to colleagues and friends about the Cuban effort, among others, suggest an architectural practice that went far beyond the acclaimed structural exuberance of his hypars. And as we consider projects as far-spanning as the rural school for indigenous children or his housing projects for remote communities, connections to contemporary practices become rather plausible. PRODUCTORA, in particular, comes to mind. Not because their projects look alike to Candela's but because both practices deploy geometries that are simultaneously efficient and generous, they sponsor a sense of agency, and they are dimensioned for the collective, or at least for something beyond the individual.

Of course, there are the obvious academic references that link the two: from the Mexican Modernism exhibition that PRODUCTORA designed in 2010 and which prominently featured Candela, to their 2012 renovation of Juan José Díaz Infante's fiberglass shells. But, more important for our purpose, are their similarly bold and precise uses of geometry. For the 2019 Urban Park in Tultitlán, for example, PRODUCTORA deployed abstract forms to create platforms for social interaction and chance encounters (FIG. 14). And, in the same year, their Housing prototype in Apán, utilized a central brick vault that accommodates all circulation, rethinks conventional room layouts, and accepts changes and expansions. By spatializing the interstitial zone between domestic spaces, the vault permits, or better incentivizes, the activities of one room to spill into the other without dictating a particular use, order, or direction. It rather anticipates and affords different forms of inhabitation and action –a projective open-endedness that allows us to conceive of the central zone to be converted into an interior just as much as it lets us foresee the expansion of the system into a series of vaults in one direction or an extrapolation into a continuous, linear corridor in the other. It is here where both practices meet and go beyond geometry–.

FIG. 14

Notes and bibliographic references

[1] Parts of this essay were first developed in collaboration with Juan Ignacio del Cueto for the essay "1:1 Models: An Experimental Architecture of Trial and Error," in *Félix Candela from Mexico City to Chicago: Rise and Fall of Experimentation in Concrete* (Barcelona: Actar, 2024). Del Cueto's many books on Candela's early period are constant points of reference for my research on Candela.
A concerted effort to build more schools in rural areas can be observed between 1936 and 1980. In 1936, the first schools for indigenous children were built in rural areas, followed by laws that made the six-year school education free and compulsory (1946), and in 1971 the newly established National Council of Educational Development was tasked to expand education in marginalized communities. By the 1980s, managing the debt crisis took precedence over government investment in education. See, Fernando M. Reimers, "The Quest for Educational Equity in Mexico," *Daedalus, the Journal of the American Academy of Arts & Science*, 4 (Fall 2024): 206-220.

[2] While this essay focuses on the qualities of Candela's shells, it is important to recognize that the process of shell construction as it was designed by Candela and executed by his firm, Cubiertas Ala, not only heavily relied on manual labor but its increasingly complex forms, coupled with rudimentary construction techniques, made for precarious working conditions that were prone to accidents. See María González Pendás, "Fifty Cents a Foot, 14,500 Buckets: Concrete Numbers and the Illusory Shells of Mexican Economy," *Grey Room*, 71 (Spring 2018); and "The Bodily Economies of Concrete Technologies," in Matthias Beckh et al., eds., *Candela, Isler, Müther: Positions on Shell Construction* (Birkhäuser Verlag, 2021).

[3] A catenary is similar to a parabola and derives its shape from a chain hanging from two points, transmitting forces in tension. Inverted, the curvature transmits forces in compression, minimizing tractions, which makes the vault slender and gives it a constant thickness.

[4] For more information on the structural properties of this experimental vault, see Garlock and Billington, *Félix Candela: Engineer, Builder, Structural Artist* (Princeton University Art Museum; Yale University Press, 2008), 65.

[5] Colin Faber, *Candela, the Shell Builder* (Reinhold Pub. Corp., 1963), 17.

[6] Drawings as early as 1948 already bear the firm's insignia, which suggests that his vision for the company was already well in place by the time partners were found. Cubiertas Ala, unambiguously called *wing roofs*, was composed of Félix and Antonio Candela, the brothers Fernando and Raúl Fernández Rangel, José Luis Certucha, and Julia Candela (the sister of Félix and Antonio), who was responsible for the bookkeeping and office administration.

[7] Carlos Recamier, interview by Juan Ignacio del Cueto, Mexico, May 21, 2007 (cassette tape, unpublished).

[8] Ibid.

[9] The contract was signed in 1952 and the work was carried out between February 18, 1953 and May 22, 1954. It brought in revenues of almost two million pesos, five times the largest contract the firm had obtained until then. See Cubiertas Ala

Catalog of Projects and Works, 52/36, Archive of Mexican Architecture at the Faculty of Architecture at UNAM.

[10] Faber, *Candela*, 33.

[11] Candela, unpublished autobiography, Félix Candela Papers, C1455, Manuscripts Division, Department of Special Collections, Princeton University Library, 22.

[12] Faber, *Candela*, 37.

[13] Ibid.

[14] Ibid., 59.

[15] Faber, *Candela*, 59: "The shape is quite similar to the Cosmic Rays Pavilion vault, but stiffening arches were omitted here."

[16] In 1957, the Cuauhtémoc Foundation and Famosa, the most important business group in Monterrey, carried out an urban development for workers on an area of 90 hectares. The development began with 334 single-family housing units and ended with a total of 1,318 homes (118 more than initially planned). It was conceived by the philanthropic interests of the Mexican businessman Don Eugenio Garza Sada.

[17] Felix Candela Papers, Drawings and Archives, Avery Architectural and Fine Arts Library, Columbia University, Box 2:3, letter from Candela to Max Borges, June 9, 1959.

[18] For an analysis of the Monterrey scheme, see Gerardo Páez, "De la utopía geométrica a la realidad arquitectónica: viviendas con paraboloides hiperbólicos en la década de los cincuenta, por Catalano en Estados Unidos y Candela en México," *Tecnología y Construcción*, 32, no. II (2016): 74-94.

[19] Felix Candela Papers, Drawings and Archives, Avery Architectural and Fine Arts Library, Columbia University, Box 38, C373rr, Series V Project Records 2003.027: "it represented a savings of up to 21.5% compared to houses with the same roof area, built using the conventional system."

[20] For an analysis of Candela's Shell House scheme presented in Havana, see Ángel Manuel Álvarez Gómez, "Félix Candela: propuesta de viviendas económicas para Cuba," *Arquitectura y Urbanismo*, XLIII, no.1 (January-April 2022): 40-51.

[21] Álvarez Gómez, "Félix Candela: propuesta de viviendas económicas para Cuba," 50.

[22] Other examples include the 30 bungalows for the Hotel Casino de la Selva in Cuernavaca, Morelos, designed by Juan Antonio Tonda and completed in 1960; six modest accommodations for employees of the Bacardí bottling plant; and the striking roof for the home of the architect Hector Alonso Rebaque in Jardines del Pedregal where the living quarters are roofed with a groin vault in three segments.

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Figures

FIG 01. Experimental funicular vault, San Bartolo, Mexico City, 1949. Source and author: ©Félix Candela Papers, Library and Special Collections, Princeton University.

FIGS 02 a & b. Félix Candela and Enrique León de la Barra, Rural School under construction and completed near Ciudad Victoria, Tamaulipas, 1951-52. Source and author: ©Félix Candela Papers, Library and Special Collections, Princeton University.

FIG 03. Candela (second from the left) and workers standing on top of mockup conoid vault for Raul Fernández, San Bartolo, Mexico City, 1950. Source and author: ©Félix Candela Papers, Library and Special Collections, Princeton University.

FIG 04. Boliches Marsella Bowling Alley, Juárez, Mexico City, 1950. Source and author: ©Félix Candela Papers, Library and Special Collections, Princeton University.

FIG 05. Candela (eighth from the right) and workers standing on top of an experimental umbrella, Vallejo, Mexico City, 1953. Source and author: ©Archivo de Arquitectos Mexicanos, Facultad de Arquitectura, UNAM.

FIG 06. Construction sequence for an inverted umbrella foundation. Published in Faber, *Candela: The Shell Builder* (1963), 93. Source and author: ©Colin Faber, *Candela: The Shell Builder* (New York, Reinhold Publishing Corporation, 1963), 93.

FIG 07. Río's Warehouse during construction, Linda Vista, Mexico City, 1954. Source and author: ©Félix Candela Architectural Drawings and Papers, Avery Drawings and Archives Collection, Columbia University.

FIGS 08 a & b. Félix Candela and Raul Fernández, Vault House and House No. 3 Entry for Novedades, Jardines del Pedregal, Mexico City, 1951. Source and author: ©Félix Candela Architectural Drawings and Papers, Avery Drawings and Archives Collection, Columbia University.

FIG 09. Félix Candela and Horacio Almada, Carport for Almada Residence, Jardines del Pedregal, Mexico City, 1951-1952. Photograph with touchups. Source and author: ©Félix Candela Architectural Drawings and Papers, Avery Drawings and Archives Collection, Columbia University.

FIG 10. Cosmic Rays Laboratory, under construction, UNAM, Mexico City, 1951. Source and author: ©Félix Candela Architectural Drawings and Papers, Avery Drawings and Archives Collection, Columbia University.

FIGS 11 a & b. Map and aerial view of Colonia Cuauhtémoc, Monterrey, Nuevo Leon, 1958. Source and author: Wikimedia.

FIG 12. Construction of a low-cost house prototype for a bungalow settlement in Monterrey, Nuevo Leon, 1958. Photo sequence published in Faber, *Candela: The Shell Builder* (1963), 124. Source and author: ©Félix Candela Architectural Drawings and Papers, Avery Drawings and Archives Collection, Columbia University.

FIG 13. Small Home after conversion from farm facility, San José de las Lajas, Cuba, 2022. Source and author: ©José Ángel Rojas.

FIG 14. PRODUCTORA, Housing prototype, Apán, 2019. Source and author: ©PRODUCTORA.

Alexander Eisenschmidt is a designer, writer, and Professor of architecture at the University of Illinois at Chicago. He leads The Housing Futures Initiative, directs the Visionary Cities Project, and is the principal of Studio Offshore. He has published extensively, and his work has been exhibited internationally. He is the author and editor of numerous books, among them are *Félix Candela from Mexico City to Chicago* (2024) and *The Good Metropolis* (2019). In addition, Eisenschmidt has curated and his research and design work has been exhibited in venues such as the International Architecture Biennale in Venice, the Art Institute of Chicago, the International Biennale on Urbanism in Shenzhen, China, the Lisbon Architecture Triennale in Portugal, and the Druker Design Gallery at Harvard's GSD. He holds a Ph.D. from the University of Pennsylvania, an M.Arch. from Pratt Institute, and a Diploma in Architektur und Städtebau from the HTWK in Leipzig, Germany.